INHERITANCE THROUGH SPORES.

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The modern history of botany is a series of segregations of subjects. Each new segregate has attracted a certain number of recruits from the older subjects. There have always been two categories of botanists: those who move on promptly to the newer phases of their subject, and the old guard that never moves on. The latest segregate of the series is plant genetics, which is making so large an appeal to botanists that if the epidemic continues all botanists are in danger of becoming geneticists. What I wish to present has a bearing upon the work of this important modern field of botanical activity. In this presentation, however, I shall not introduce the details of material. These details are too numerous for the time allotted, and too technical for any audience excepting one of professional botanists.

Plant geneticists have begun, just as did plant morphologists, by using the most complex material. So long as plant morphologists focused their attention upon seed plants, they were accumulating data that could only be interpreted empirically. When they included a study of the lower forms, the simpler groups became keys to the more complex ones, and interpretation became scientific. In plant genetics we are still mainly in the stage of complex material. Sexual reproduction is selected as the method of reproduction to be investigated, and the particular sexual structures selected are so peculiarly involved with other structures that it is impossible to analyze the factors involved in the results. Not only are the sexual structures beyond the reach of observation and of experimental control, but there is an alternation of two forms of reproduction, inheritance being carried through one generation to express itself in the next.

Furthermore, the origin of embryos produced in seeds is not assured. While we may assume that, for the most part, they are the result of fertilization, which in its gross aspects can be controlled, the increasing number of cases of parthenogenesis, vegetative apogamy, and sporophytic budding introduces a serious element of uncertainty. The program between pollination and fertilization, and between fertilization and the escape of the embryo from the seed, is a very long one, and not a single stage of it is under observation, much less under control. In other words, we are working empirically upon our problem as yet.

If sexual reproduction must be studied, it would seem desirable, therefore, to use material selected from the more primitive sexual forms, material in which the sexual structures are not so involved with other structures, in which the whole performance of fertilization and embryo development is in sight and capable of control. The difference between a sex act and an embryo development under cover, and in the open, when experimental control is the end in view, is too obvious to need further explanation. Furthermore, in these simpler sexual forms the origin of sex is observable, so far as it is represented by the sexual cells, and the general conditions of origin are known, conditions which are sadly in need of analysis in experimental work. It must be evident that a knowledge of the factors involved in the origin of sex may throw some light on the function of sex in general. But the origin of sex involves a still more fundamental problem.

Sexual cells are phylogenetically related to spores, that is, spores are historically intermediates between vegetative protoplasts and sexual cells. This suggests that the origin of spores and inheritance through them deserve attention as a preliminary to the origin of sexual cells and inheritance through them. In other words, there are certain things that all forms of reproduction have in common, and these should be kept distinct from the things which are peculiar to sexual inheritance.

More primitive than reproduction by spores is reproduction by ordinary protoplasts, shown notably by one-celled plants in which cell division results in reproduction and in which the succession of

cell divisions is rapid. The fact that such plants can be induced to form spores contrary to their normal habit, indicates that the conditions of spore formation can be determined. These conditions are described as yet in terms so vague that they mean little more than environment, and this may be external or internal, depending upon whether one speaks from the standpoint of the plant or of the protoplast. Experimental work has shown that a spore may be defined as a protoplast, usually separated from its old wall, always separated from organic connection with other protoplasts, and by virtue of this latter fact, capable of producing a new individual. If this is a spore, what is a sexual cell which may be derived from the same protoplast? Neither of them is a protoplast of special cell lineage, as has been proved by inducing spore formation and gamete formation in any cell lineage.

The plant geneticist may not be interested in the conditions that result in gamete formation, and even less interested in the conditions that result in spore formation, but these are fundamental to the problem of reproduction, and therefore fundamental to the problem of inheritance. A practical plant-breeder may be interested only in the fact that he can obtain a new individual from a seed, the pedigree of whose embryo in the nature of things cannot be demonstrated, but only inferred; but a scientific plant-breeder, whom we now call a geneticist, must be interested in the conditions that determine inheritance, and these include the conditions that determine reproduction in general.

No more favorable material for determining the fundamental facts of inheritance can be found among plants than spores of the simpler forms. They are accessible, and therefore capable of control; a succession of spore-produced individuals represents a line whose purity cannot be questioned; the so-called "modification of the germ plasm" can be accomplished with a precision that is impossible in an ovary and ovule-enclosed egg, to say nothing of the sperm. In short, freed from all entanglements of sex, the possibilities of variation in pure lines can be determined, and the possibilities of the inheritance of such variations. Such work will establish the facts common to all inheritance, and will enable us to recognize the contribution of sex to inheritance.

To indicate that this is not a visionary programme, I wish to say that such experimental work has been begun, and that the initial results indicate that the stage of promise is merging into the stage of performance. It is demanding not merely the technique of plant-breeding, but it involves also the technique of cytology to discover the structural changes, and the technique of physics and physiological chemistry, to determine the conditions and substances that are factors in the various processes. Perhaps of largest significance is the fact that just as the doctrine of evolution broke up a static taxonomy, so this experimental work with inheritance is breaking up a static morphology, encrusted with rigid definitions, and is making this great field dynamic.